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AUTHOR Estes, R. C.
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ABSTRACT

This document is a description of the energy efficient designs for new schools in the Alief Independent School District of Houston, Texas. Exhibit A shows how four major school projects differ from conventional designs. Parameters and designs for heating, ventilating, air conditioning, and lighting are given. Twenty year projected energy costs and computer estimates of costs for various designs are included. Wind generators for emergency and exterior lighting, and solar collectors for heating water are part of the design criteria. Methods of introducing such plans to a school board are suggested. (TM)

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DESIGNING FOR ENERGY CONSERVATION

R. C. ESTES

DIRECTOR

FACILITIES PLANNING AND CONSTRUCTION

ALIEF INDEPENDENT SCHOOL DISTRICT

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DESIGNING FOR ENERGY CONSERVATION

With the continual increases in energy costs throughout the nation, many school districts are beginning to look for ways to decrease energy consumption in existing buildings and to create energy efficient structures in new construction.

Alief Independent School District has been successful in obtaining energy efficient designs for its new schools by developing energy goals prior to the selection of architects and engineers. These goals are given to the design professionals prior to their interview. The professional's understanding of the district's requirements is an important factor during the interview process. The district has four major projects designed to conserve energy; two elementary schools, a school bus transportation center, and a natatorium. Exhibit A shows how these projects differ from conventional designs.

The annual energy budget for the new facilities is 44,000 BTU's per square foot; however, a designed engineering estimate for energy consumption of the district's ninth elementary school is projected at 16,500 BTU's per square foot. Perimeters for the heating, ventilating, and air conditioning design are based on weather data that indicates temperatures will rarely exceed 91° prior to two o'clock in

the afternoon during the school year. This design also takes into consideration that Houston, Texas has very mild winters with most of the low temperatures taking place at night or early in the morning. Outside temperatures have less effect on well insulated buildings because it takes longer for the outside conditions to penetrate the building envelope.

The interior designs for heating and cooling are the same as recommended by the American Society of Heating, Refrigerating, and Air Conditioning Engineers. Alief's goal is to have air conditioned buildings that the District can afford to operate in the future. The interior design of 78° for summer is higher than commonly desired. This will require persons to wear light weight clothing to be comfortable. These new facilities are designed to effectively contain cool air in the summer time and warm air in the winter. The buildings do this five times more effectively than a kitchen refrigerator.

An excellent U Factor of .04 is obtained by using ample insulation, insulated skylights, vestibles, earth berms, and glass in areas protected from the sun. Heat resistive skylights were used extensively in the district's ninth elementary school. The bold black horizontal lines on Exhibit B show where the heat resistive skylights are located throughout that school. The light coming through the skylights is monitored by sensors shown in Exhibit C. When the natural light level reaches sufficient brightness, the energy indicator lamp is

activated telling the teacher that artificial lighting may be reduced. At that point, the teacher may turn off 1/3, 2/3, or all of the lights in the classroom area. A computer study indicates that the building will consume less energy with the skylights than without them. That study is shown in graphic form at the bottom of Exhibit D. The average monthly cost for energy of the school with skylights was \$941. The same school designed without skylights has an estimated energy cost of \$1,080. The top part of the graph shows the actual cost of energy consumed by the district's seventh elementary school. Elementary #7 and #9 are semi-open in design and each provide for enrollments of 1,000 pupils. The seventh elementary school is the smaller of the two. The energy costs for the ninth elementary school with skylights and the seventh elementary school are projected over the next twenty years. That projection, shown in Exhibit E, assumes that energy costs will continue to increase each year at 12%. The twentieth year the projected costs for energy for the seventh elementary school is \$217,000 more than the cost for energy required by the ninth elementary school. The cumulative cost difference for energy over the twenty year period is almost \$1.4 million.

Lighting is important in the design of these buildings because not only does it consume energy but it also creates heat. Thirty-six per cent of the air conditioning requirements

for schools in Alief is created by body heat while another thirty-six per cent is caused by heat generated in lighting the building. The quality of light in these four facilities has been increased by using indirect lighting and the quantity of light has been decreased. The lighting limits are 1.2 watts per square foot^{with 45 foot candles} of usable light in the instructional areas. Additional savings have been obtained by using high pressure sodium lights and fixtures with parabolic reflectors.

Wind generators have been introduced into the design criteria because of a gift. An engineering firm, challenged by the school district's energy goal, purchased two wind generators and storage batteries with their own funds. Therefore, a wind generation system was incorporated into the school district's first energy conservative school. These generators provide the energy needed for the emergency and exterior lighting systems.

The heating and air conditioning requirements for an energy-efficient building are quite different from previously designed buildings. In this area of Texas, heating is seldom needed; in fact, these facilities require cooling over 95 per cent of the time. Even though the air conditioning operates most of the time, the amount of energy used for air conditioning has been reduced because of the building's U Factor and lighting

system. Refrigerated air is supplied in these buildings by electric water to air heat pumps. Space heating and hot water are supplied by solar collectors while outside air has been reduced to 2½ cubic feet per minute per person.

Because they require more hot water, the transportation center and the natatorium utilize the water to air heat pumps more effectively than the two elementary schools. The heat rejected from the heat pumps while operating on air conditioning cycle provides additional help in supplying the required water. The transportation center uses hot water for washing buses, for space heating, and for normal domestic uses. Most maintenance shops use suspended heaters, which attempt to force warm air down with fans. In this facility, radiant heating is provided by circulating hot water inside the concrete slab where bus maintenance is performed. The design is meant to keep the mechanics' feet warm and capitalize on the fact that heat rises. In addition to heating the concrete, the piping system may also be used in the summer to circulate low temperature water.

"How did you get the design approved by the School Board?" and "How can you afford to build that kind of school?" are questions usually asked when the Alief energy efficient designs are discussed. Energy design efforts started because of the CEFP convention in 1976, dealing with energy conservation. An energy consciousness was a result of that meeting and conservation became a topic of discussion with the superintendent,

the business manager, the director of maintenance, etc. Articles concerning conservation techniques used in the construction process were shared with staff and board members. A guest speaker was invited to talk with the school board about solar applications and how they could be used in future schools. The district's business manager developed an energy conservation program involving rebates. Because of those efforts, energy conservation was being discussed throughout the district and the school board was ready to approve designs for energy-efficient schools.

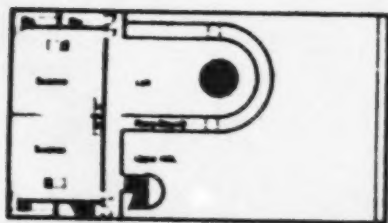
In response to the second question concerning cost, Alief has found that buildings designed to conserve energy cost the same to construct as conventional schools. For example, the district's eighth elementary school was not designed to conserve energy while the ninth elementary school was planned using an energy efficient design. The construction costs per square foot of each of those schools was the same when an inflation factor was included in the comparison.

Every school district is unique and needs to develop its own standards for designing energy conservative buildings. Initial costs of such projects will soon be offset by the savings realized in the future. Efficient use of energy today can significantly affect the amount of energy available in

the future. Every district in America should investigate the potential and utilize the possibilities for incorporating energy efficient designs and ideas in their present and future facilities.

DEVIATIONS FROM STANDARD DESIGNS

- I. Commitment to design and construct energy conservative buildings prior to selection of architects and engineers.
 - A. Establish an energy budget-current budget is 44,000 BTU's per square foot annually.
 - B. Establish perimeters for design of supplemental HVAC.
 1. Outdoor design.
Summer - 91° and 76° F.W.B.
Winter - 34° F.D.B.
 2. Indoor design.
Summer - 78° F.D.B. and 50% R.H.
Winter - 72° F.D.B.
- II. Overall Building U Factor of .04.
 - A. Roof and walls to contain at least 3½" of insulation.
 - B. Heat resistive skylights.
 - C. Glass only in shaded areas.
 - D. Double glazing
 - E. Vestibules.
 - F. Earth Berms.
- III. Supplemental Lighting.
 - A. Limit to 1.2 watts per square foot.
 - B. Limit to 45 raw foot candles in Instructional Areas.
 - C. Limit Equivalent Sphere Illumination to 30.
 - D. Indirect lighting.
 - E. High Pressure Sodium.
 - F. Parabolic reflectors.
 - G. Wind generators for lighting.
- IV. Supplemental HVAC Systems
 - A. Electric water to air heat pumps.
 - B. Solar collectors for heating.
 - C. Outside air = 2.5 CFM/person.
- V. Conservation Graphics
 - A. Educational
 - B. Changeable
 - C. Dynamic



Second Floor Plan

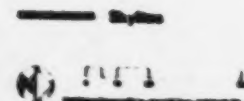


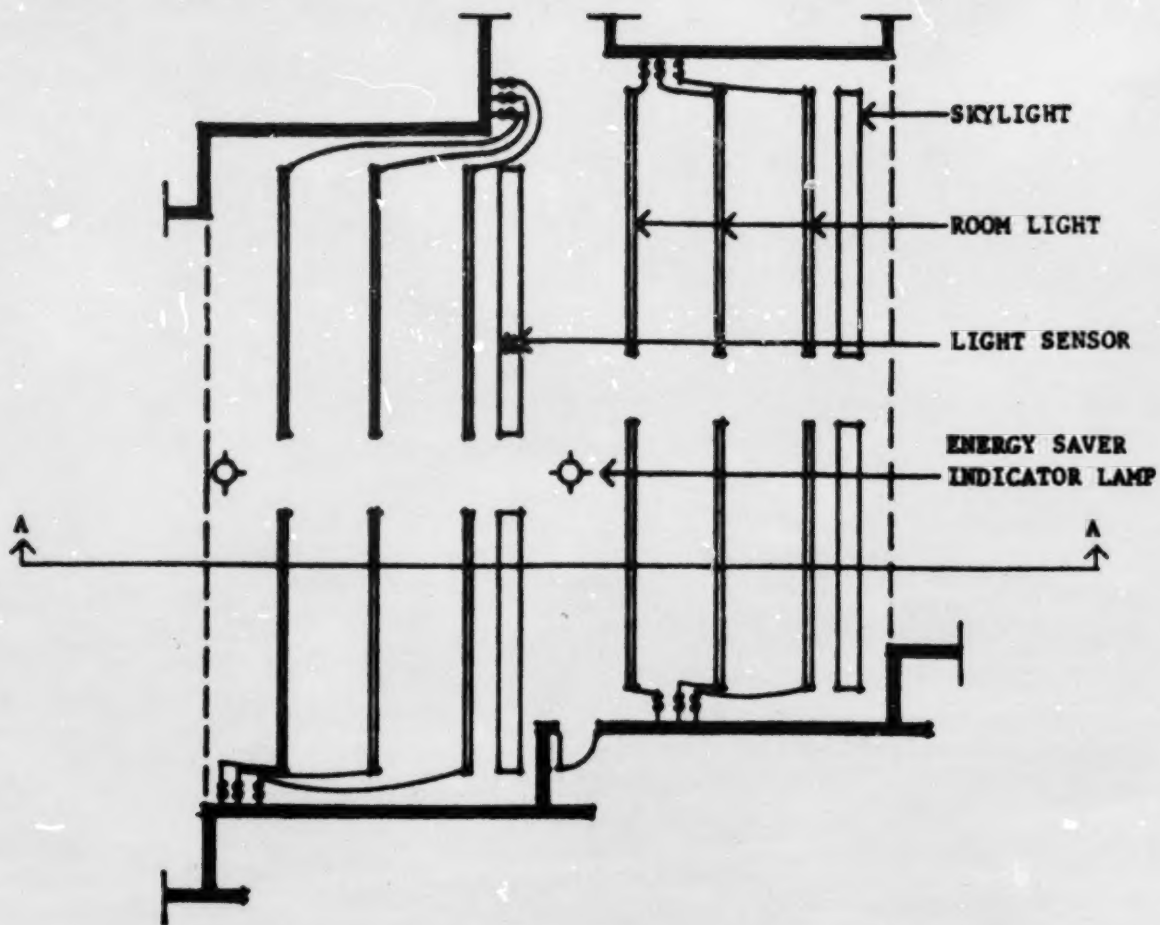
First Floor Plan

11

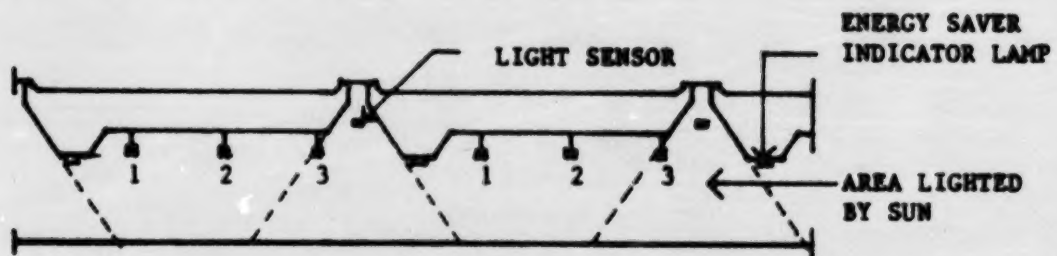
EXHIBIT B

12





TYPICAL CLASSROOM LIGHTING PLAN



SECTION A-A

NOTE:
 WHEN 45 FOOT CANDLES AT DESK HEIGHT OR MORE SUNLIGHT IS COMING THROUGH THE SKYLIGHT, THE INDICATOR LIGHT COMES ON. A STUDENT THEN TURNS OFF SOME OF THE CLASSROOM LIGHTS, THUS SAVING ENERGY. LIGHTS 1 & 3 CAN BE TURNED OFF, 2/3 OF CLASSROOM LIGHTING.

EXHIBIT D
Original 11" x 17"

